ON THE

NECESSITY *for* CONTRACTING CAVITIES

Between the VENOUS TRUNKS and the VENTRICLES of the HEART;

ON THE

USE OF VENOUS SINUSES IN THE HEAD;

On the Wonderful Provision made for the Transition

from the

FOETAL TO THE BREATHING STATE;

ON PALPITATION; ON DEATH; AND ON LIFE:

With

REFLECTIONS on the TREATMENT of ANIMALS.

BY JOHN WALKER.

OMNIA enim quae quidem inclusa sunt ita nata atque ita locata sunt, ut nihil eorum supervacaneum sit, nihil ad vitam retinendam non necessarium ---doceat ergo aliquis potuisse melius: sed nemo unquam docebit et siquis corrigere aliquid volet, aut deterius faciet, aut id quod fieri non potest, desiderabit. *Marc. Tul. Cicero*

Edinburgh:

PRINTED BY T. MACCLIESH AND CO.

FOR WILLIAM MUDIE; AND DARTON AND HARVEY, LONDON.

1799.


BRITISH MUSEUM

A la SOCIETE *de* MEDICINE *de* PARIS, *à la* SOCIETE MEDICALE *d'* EMULATION, *et au* LYCEE *des* ARTS *de* PARIS.

JE ne voudrois pas en quelque manier livrer à l'oubli et a l'inutilité entiér ce petit ecrit que j'avois mis en Latin afin qu'il me ſervit de Diſſertation inaugurale, mais que je ne fis pas imprimer a Leyde, faut de temps ; ainſi, je vous le preſente, dans une langue moderne, qui n'eſt pas inconnue à pluſieurs de vous. Il me fournira en meme tems le moyens de vous tranſmettre quelques obſervations qui ont raport au ſentiment plutot qu'à la phyſiologie.

Qu'il eſt agreable ! qu'il eſt conſolant ! de voir " que la veritable ſcience ne connoit point d'en- " nemis." —— Ma reception comme membre de vos Societés dans un temps ou le Gouvernment du päis on vous tenez vos aſſemblées, et celui du päis qui m'a vu naitre cherchoient a ſe detruire mutuellement, en eſt une preuve trop grande et trop generçuſe, pour la paſſer ſous ſilence.

Helas qu'il eſt triſte de voir les diſputes politiques renvoyeés à un tribunal que la philoſophie diſavoue, et que le droit ne ſe decide que par la force ! Quand ceſſera 't on enfin de repandre le ſang humain, et de terminer leur differents autrement que la bete feroce !

Je vous preſente ce coup d'eſſai avec cet eſpoir qu'il renferme quelques idées neuves ; il ſe peut pourtant que cet eſpoir n'eſt fonde que ſur mon ignorance des ouvrages qui ont traité de ce ſujet.

Quoiqu'il en ſoit de ſon merite j'eſpere que vous voudrez le recevoir au moins comme un foible temoignage de ma reconnoiſance.

J. W.

A Rotterdam, 14 Thermidor, an 7.

TO THE

ROYAL MEDICAL SOCIETY

OF EDINBURGH.

WERE I to omit here the acknowledgment of your favour in voting the reading of this paper in your meeting, and appointing an extraordinary meeting for its further diſcuſſion, the omiſſion might give an appearance of apathy on my part, which does not belong to me. I felt extremely ſenſible of your generous kindneſs to me at the time; and, if the remembrance of it be like to carry to my heart a ſoft, inſinuating, flattering, gratification, I know, at the ſame time, that there are better feelings to be excited by it than thoſe narrow ones founded only on ſelf-love. If I look at your conduct aright, I may taſte the pleaſures and derive the profit which ariſe from the contemplation of the acts of liberal minds.

The firſt ideas, on the ſubject of this paper, aroſe, during a converſation in Holland on commercial affairs, in which, not feeling intereſted, I was led into a train of thinking on the motion of the heart and arteries, then moderately quickened by temperate draughts of wine.

It was written under circumſtances which forbade my informing myſelf of moſt of what had been already written on the ſubject; and I was ſo ignorant, as to imagine that the idea which occurred to me on the moſt obvious uſe of alternating cavities at the heart was quite new.

Of the few books within my reach, at the time, Cheſelden's Anatomy was uſeful to me on my commencement; and before I had completed it, I had an opportunity of conſulting Blumenbach's Phyſiology. I alſo derived ſome information from the *Ontleedkunde van Plenk door Geſcher*, from Gregory's Conſpectus, and from a few odd numbers of the Monthly Review, of which I do not now remember the dates.

If I have not availed myſelf of the criticiſms made in your ſociety, to the improvement of this paper, it is becauſe I wiſhed to give it in its original form, in order to afford to my particular friends the ſatisfaction of ſeeing, a little, what were my labours before graduating, and to ſecure from others the indulgence always due to an Inaugural Eſſay.

J. W.

Edinburgh, 21. xii. 1799.

The object in printing this Eſſay in different ſized letters, was to make the parts of inferior importance, or of tedious detail, retire as it were from the eye under a ſmall character, that the reader might the more eaſily connect the leading ideas, which are attempted to be exhibited, under a larger letter.

There is an obſcurity in the laſt paragraph of page 22. I ſuſpect the accuracy of that reaſoning, whereby I formed the concluſions therein contained, and propoſe the following change.

For the tendency of the blood, &c. *read,*

The reſiſtance made to the blood's paſſing through the *foramen ovale* continually increaſing from the firſt unfolding of the lungs, is effective from the moment of the cloſing of the *ductus arterioſus.* At this time the force of the right ventricle, employed previouſly to birth, upon the placental and greater ſyſtems, as well as upon the pulmonary one, being wholly ſpent upon the laſt, is competent to charge fully the left ſinus—the *foramen ovale* is ſoon completely ſtopt, and the circulation, ſuited to the being of a breathing animal, is fully eſtabliſhed.

I. ON THE MOTIONS OF THE HEART UNDISTURBED.

IN what way can we account for the tranquillity of the thorax, while the heart is in health and undiſturbed, although the motions of this organ are vigorous and unceasing within it?

1. *a.* While every muſcle, which is exerciſed only in obedience to the will, preſently flags and tires, how wonderful, how aſtoniſhing, are the energies of the heart, which, whether we ſleep or are awake, and even when by apoplexy the animal powers are ſuſpended, unremittingly labours, or rather acts, and never becomes ſenſible of fatigue through all the changes of life!

b. For, however harraſſing may be the anxiety produced by its obſtructions, or morbid actions, it perhaps is not, itſelf, the ſeat of the ſenſation, at leaſt the muſcular part of it, which is not furniſhed with diſtinct nerve, but only with medullary pulp, a diffuſion, however ſubtile, of nervous ſubſtance being perhaps always neceſſary to irritability throughout the whole of organiſed creation.—But I am wandering from the queſtion.

How comes it, that while ſuch vigorous action is carried on by this ever moving muſcle, a correſponding appearance of motion or agitation is not produced on the thorax?

2. *a.* At the moment of my writing this, I touch faintly a branch of the temporal artery, and feel diſtinctly what is going on: I throw one leg over the knee of the other as I ſit, and diſtinctly ſee the effects of the action of the heart and arteries, in the vibrations of my pendent foot over the floor;

b. While I find it impoſſible whether ſitting, ſtanding up, or lying down; wherever I apply my hand, and with whatever degree of preſſure, to feel the leaſt ſenſation of the motion of the heart.

3. *a. a.* Till running ſeveral times up and down ſtairs, the pulſe riſes to 148 ſtrokes in a minute, and I diſtinctly feel, and imagine I alſo ſee on the thorax, the effect of the tumult raiſed within,

b. a. Excluſively of that of the anhelation under which I labour from the experiment.

a. b. The velocity of the pulſe, it may well be conceived, was but of momentary duration; while the exerciſe which produced it was ſufficiently violent to give me a head-ach during the whole day.

b. b. The cauſe of the anhelation is not the buſineſs of this paper; yet it may be briefly obſerved, that the neceſſity of quickened reſpiration may appear obvious, from the conſideration, that whatever changes the blood have to undergo from the inſpired air, if by any means it be made to paſs quicker through the lungs, the air muſt be afforded proportionally quicker, the blood being in the ſame ſtate as when it's motions were ſlower;

b. c. And as on ſuch occaſions the motions of the heart and arteries muſt become quicker or ſtronger, hereby producing diſtenſion of veſſels and increaſed action in different parts, or acceleration of the natural functions,

b. d. Cauſing ſenſible heat, and expanſion of the circulating fluid at the ſame time,

b. e. It ſeems not difficult to conceive, that this muſt need the renovating effects from reſpiration proportionally ſooner, as the actions in the general ſyſtem have been accelerated.

Neceſſity for an even number of alternating cavities.

It hath been an axiom with Phyſicians, that nature abhors a vacuum.

That law in creation which gave riſe to the axiom might as well be defined, A diſpoſition in matter to unite itſelf cloſely, leaving the immenſity of ſurrounding ſpace to become void, the vacuum being only guarded againſt by motion being inſtituted, as far as we can obſerve, throughout the whole univerſe.

4. That law renders an alternation of motion in cavities neceſſary at the heart, which is the organ that gives the impetus which principally effects the circulation of the blood.

4 *a.* The motions of the ventricles of the heart being ſynchronous, if this vital organ (I mean here the heart as compoſed of two ventricles) were without appended contracting cavities, on the ventricles contracting and thus ſuddenly diminiſhing

its volume, the parts ſurrounding it would have as ſuddenly to cloſe over it, to prevent a vacuum, and then to retire in yielding to its enlargement.

Each ventricle of the heart having at its entrance an auricle, which with the adjoining ſinus forms one continued cavity---this whole auricular appendage of the ventricle or ſinuous termination of the veins has been termed the atrium. It has alſo been diſtinguiſhed by the general term ſinus, which latter name is here adopted.

b. The ſinuſes enlarging during the ſyſtole of the ventricles, and contracting during their diaſtole, the hurtful agitation is prevented which would have ariſen from a heart conſtructed with ventricles only:

Moreover, the heart being ſurrounded by the lungs, whoſe ſubſtance, or rather ſtructure, is the moſt yielding of any ſolid in the body, cannot, when its actions become inordinate, produce ſo hurtful an agitation in the region which it occupies as it would have done had it been placed in any other part of the body.

5. *a.* Amphibia and fiſhes, different from mammalia and birds, are ſaid to have only one ventricle and one auricle for the circulation of their comparatively cold blood;

b. But the heart of ſome of the amphibia ſeems to be ſo conſtructed as to act as a ſingle heart, when the animal is under water, though in the air it may be capable of effecting the long circulation.

"In a water tortoiſe, (ſays Cheſelden in his Anatomy of the human bo-
"dody, book iv. near the end of chap. iii.) which I had an opportunity
"of examining with that moſt dexterous and indefatigable anatomiſt Dr
"Douglaſs, I found the two ventricles of the heart but half divided by a
"ſeptum, and in the beginning of the pulmonary artery, ſeveral ſtrong
"muſcular rings, a little diſtant from each other, each of which, by
"contracting, would be capable of reſiſting a part of that blood, which
"otherwiſe would have been thrown into the lungs, when they were un-
"der water; and this blood ſo obſtructed muſt neceſſarily be thrown
"into the aorta, the two ventricles being in a manner one common ca-
"vity; and when they are out of the water, this communication of
"ventricles will ſuffer but little confuſion of the blood which flows into
"the ventricles, becauſe each ventricle receiving and diſcharging the
"ſame quantity of blood, at the ſame time, they will balance each other,
"and thereby ſuch a mixture will be very much prevented."

c. Inſects and worms, which have not blood, but only a ſerous fluid circulating through their bodies, having only one ventricle, and no auricle or ſinus, may ſeem to contradict the notion of the neceſſity of alternating cavities at the heart.

But it is eaſy to conceive that this enlargement of ſeriferous canal, by an undulating ſucceſſion of enlargement and contraction, or by its periſtaltic motion, may be com-

petent to effect the languid circulation neceſſary to their dull life: in which caſe, as we do not ſee one diſtinct contractile ſack acting ſimultaneouſly throughout its whole length; ſo, neither does it appear neceſſary, that there ſhould be a ſecond contracting cavity to conſtitute evenneſs of number between vein and artery, as in warm blooded animals, where the circulation is rapid, and the contractions of cavity ſtrong and diſtinct.

6. *a.* Would the agitation, which the ventricles may tend to produce, be ſtill more effectually prevented, if there were another pair of contractile ſacks between the veins and the ventricles? Perfectly the reverſe, I believe. A ſecond pair would produce the agitation which one pair (the ſinuſes) prevents, and would require a third pair to reſtore the equilibrium or tranquillity.

b. Thus then it appears to me, that the whole number of contracting ſacks of the heart (ventricles and their appended cavities included here in the term heart) between vein and artery, as between the *cavæ* and pulmonary artery, and as between pulmonary veins and *aorta*;

c. Or, at leaſt, between *cavæ* and *aorta*, muſt be even, in order that the motions may be performed without too much agitation.

d. It is almoſt unneceſſary to obſerve, that the cavities here mentioned, ſuppoſitious or real, are conſidered as each tranſmitting the whole ſtream of blood. Analogous cavities on the venous trunks would require to be as numerous as the trunks. Thus, on the four pulmonary venous trunks, four ſinuſes, one on each, would only be equivalent to the ſinus at the left ventricle, the one capacious cavity at their termination. As ſuch equivalent cavities cannot be termed one cavity, they may be called, collectively, one ſet of cavities. Their motions are all ſynchronous, and are all combined to produce one effect.

7. *a.* If on the one hand the large veins near the heart poſſeſs muſcular powers (as their ſtructure ſeems to indicate) and perform a ſort of contractions (as the more than natural venous pulſe, obſervable in the upper *cava*, if at any time the blood be impeded in its paſſage into the lungs, ſeems to prove) while the ſinuſes are dilating, and thus ſeem to diſprove the neceſſity of an *even* number of contracting ſacks between vein and artery,—on the other, the contractions of the large arteries, alternating with such

venous contractions, may be conſidered as ſupplying the place of the *third* pair already mentioned. (6. *a.*)

b. Thus then while there is an *even* number of diſtinct contractile ſacks (ſinus and ventricle) between the largeſt veins and arteries, theſe themſelves near the heart participating of the nature, or exerciſing in a certain degree, the functions of the contractile ſacks may be conſidered as keeping up the neceſſary *evenness* in number of alternately contracting cavities, or ſets of cavities, (6 *c. d.*) between the more multiplied and extended branches of the venous and arterial ſyſtems: (10, *b. c. d.*) and

8. *a.* While by yielding to dilation, and having conſequently ſucceeding contractions, they diffuſe throughout the ſyſtem, the effects of the grand impetus at the heart, (the arteries progreſſively and with conſiderable force, the veins retrogreſſively, with ſmall and ſcarcely ſenſible effect, and only to a ſmall diſtance. (7 *a.*)

b. Do not the faint contractions of large veins, with the nearly ſynchronous ones of the ventricles, while all is tranquil, make a whole effect of contraction nearly equal to that of the ſinuſes (which is much feebler than that of the ventricles) together with that of the large arteries (which muſt be much ſtronger than what takes place on the venous ſide of the ſinuſes) and thus more effectually prevent agitation. (10. *b. c. d.*)

Effect of alternating cavities on arteries and veins.

9. *a.* Whatever advantage is produced by the mechaniſm of alternating cavities, about the region of the heart, muſt alſo be felt more or leſs, nearly throughout the whole ſyſtem; for, the inſtant when the large arteries ſwell is alſo the time when the ſinuſes by enlarging begin to diminiſh the volume of the large venous trunks, (7. *a.*) and thus make room for the ſwell of the arteries. (10. *c.*)

b. The arteries alſo in their ſwell as propelled

to the remote branches, ſeem by lateral preſſure, on their accompanying veins, even in parts remote from the heart, to forward or accelerate their contained fluid, in its progreſs to this organ.

c. I am ſenſible that the flow of the arterial wave is exactly in a contrary direction to the venous current; but the *vis a tergo*, and oppoſing valves, forbidding a retrograde courſe of this, it muſt be forwarded to the heart where alone the veins are diſcharged. Beſides, when lateral preſſure is made by the pulſation of an artery on its accompanying veins, its contraction immediately following its undulatory ſwell, gives ſpace for the venous current.

d. If there were not an alternation in the motions of the cavities at the heart in effecting the circulation of the blood; if the number of the cavities were not *even*, the agitation moſt ſtrongly marked on the thorax, would be felt and even ſeen throughout the whole body. (4. 5. 6. 7. 8.)

e. (4. 5. 6.) The cheſt, which now ſwells and contracts in a manner evident to the view during the moſt eaſy reſpiration, would then, inſtead of exhibiting thoſe free and gentle motions, which diſtil comfort to the ſympathetic obſerver, ſo ſilently indeed that he ſcarcely marks it, but which he finds to have been preſent, when uneaſy ſenſations are awaked in him; as by the preſence of a perſon labouring under difficult reſpiration, or when contemplating on a dead body, and forgetting for a moment that it is inanimate, he is aſtoniſhed that it does not reſpire, and feels a tranſient and evaneſcent horror, as if his own lungs were about to ſtop—the cheſt would be ſhaken in all its movements, the breaſt would quiver under inſpiration, and the breath only eſcape in jerks.

f. (4. 5. 6. 7. 8.) Every ſyſtole of the heart would produce a turgidity in every member, and every diaſtole a diminution of volume. The exiſtence of delicately ſenſible organs as of the eye and ear, is incompatible with ſuch a ſtructure; a firmer compages of veſſels than that of the human body could not long ſuſtain it.

b. In conſidering the compound motions of the heart and its appendages, is there not a fitneſs in aſſociating the alternations of ſack with ſack and of tube with tube, rather than thoſe of ſack with tube or of tube with ſack? for although the more ſudden dilatation of arterial trunks may ſeem, better than that of the ſinuſes, to correſpond with the ſyſtole of the ventricles in point of time, the caſe muſt be otherwiſe in point of ſpace: for the immediate effects of the motions of the ſinuſes and ventricles muſt be local, while thoſe of the arteries muſt be comparatively extended and diffuſed, promoting in their great trunks the alternations of the correſponding

venous trunks, and aiding, as already observed, the venous currents throughout their whole lengths.

Advantage of the presence of sinuses.

10. *a.* But if the motions of the ventricles had been alternate instead of synchronous, might not sinuses have been dispensed with, and would not the structure have been more simple, a quality of all the most excellent (in every organization where nothing is superfluous)—in every machine?

b. As the contractions and dilatations of the sinuses are not quite equal to those of the ventricles (these being furnished with valves, which in preventing the retrogression of the blood, during the contraction of the ventricles, may be said to prevent also its ingress from the sinuses at the same time; while the sinuses, even during contraction, as well as at the time of dilatation, remain open at their mouths for the admission of blood from the veins) so an advantage arises from the real structure of the heart which it could not have possessed from the more simple formation now proposed.

c. The larger arteries swell while the ventricles contract, sooner than the large veins contract, notwithstanding the continual openness of the sinuses, and more fully also because of this disposition in the sinuses.

d. It is therefore convenient that the sinuses do not become so much augmented in bulk as the ventricles are diminished by their contractions, in order that the equilibrium may be kept up between the simultaneous dilatations and contractions of different cavities. (8. *b.*)

e. It may be observed that the corresponding contractions and dilatations of the different cavities are not perfectly synchronous or of the same duration; for the contractions of the ventricles and dilatations of the large arteries are earlier and quicker also (13 *a*) than the corresponding dilatations of the sinuses and contractions of the large veins:

f. But, from the circumstance of the ventricles and large arteries alternating in their motions, as do the large veins

and ſinuſes; or, from the aſſociation of venous trunks with ventricles, and of the ſinuſes with large arteries in their motions, the whole effect of contraction, in point of time as well as of ſpace, in the contracting veſſels during their ſyſtole ſeems balanced with that of the diaſtole of thoſe which are dilated at the ſame time. (8. *b.* 10. *b. c. d.*)

In other words, is not the greater ſuddenneſs of contraction of the ventricles, than of dilatation of the ſinuſes, ballanced or compenſated by the more ſudden dilatation of arteries than of contraction of venous trunks?

g. And, equality of effect, in point of time as well as of ſpace, or of motion as well as of quantity, muſt be neceſſary to prevent hurtful agitation.

h. Beſides, the ſpeedy contraction of ventricles when the arteries, as it were, ſwallow their contents, clears the way, if I may ſo expreſs it, for the current from the inert veins and even comparatively feeble ſinuſes; and the ſpeedy dilatation of arteries affords lateral preſſure on the veins to quicken the ſaid current through them. (13. *a.* 9. *b.*)

i There may be other advantages alſo from the preſence of ſinuſes, of which farther on.

Neceſſity for the preſence of ſinuſes.

11. If the heart had been formed without ſinuſes and the motions of the ventricles had been alternate inſtead of ſynchronous, the advantage already mentioned ariſing from the ſimultaneous filling and emptying of different cavities of the heart (4. 6.) and from the ſwelling of arteries ſimultaneouſly with the yielding of veins would have followed very effectually. (9. *b.*)

12. *a.* But the blood muſt have accumulated inordinately, by its ſudden and total interruption at the entrance of each cavity, abſolutely cloſed up by valves during each contraction, and a pulſation been felt in the large veins retrograding with violence.

b. This could not long have continued ſo--- The laſt portion of vein near the heart muſt have dilated, and acquired the contractile power, and performed the functions of the ſinuſes, *receiving while they diſcharge.* (10. *b.*)

c. By this diſpoſition in the ſinuſes the neceſſity of larger cavities is ſuperceded;

d. And by this alſo the ſhock from the impetus of the heart ſeems to be guarded againſt in the venous ſyſtem, which otherwiſe might have pulſated ſtrongly, even to ſome of the ſmaller branches, though in a retrograde direction.

13. *a.* The ſpeedy contraction too of the ventricles (the ſyſtole employing about one third of the time of the pulſe of the whole heart, which might ſeem to agree with the obſervation, that the interval of the contraction of muſcular fibres, after a relaxation, and before a new one takes place, is greater in ſtrong than in weak ſubjects; but, that the contraction is performed with greater velocity; for the ventricles are certainly ſtronger ſubjects than the ſinuſes; but then the venous trunks act ſynchronouſly with the ventricles; while the arteries ſynchroniſe with the ſinuſes.)

The ſpeedy contraction of the ventricles ſeems to contribute to prevent retrograde pulſation in the veins, by cauſing a ſhorter interruption of the current of the venous ſtream.

b. More particularly, if blood paſſes during diaſtole into the pulmonary artery, (23. *c.*)

c. While on the left ſide (21. *b.*) of the heart, where this does not happen, the largeneſs of the ſinus, and the influx of the blood into it in four ſtreams, ſeem adapted to prevent, at the ſame time, the reaction of the blood, from ſtrong contractions of the left ventricle.

d. The pulmonary veins are of leſs capacity than thoſe of the greater ſyſtem,

With this view, perhaps, that the blood may not tarry, whether oxygenated, calorified, or both, to get carbonated and hydrogenated in any degree, before its entering the left ventricle to be diſtributed through the body;

e. And alſo that the lungs may not be charged with a weight, which might impede the vital functions.

Defence of remote parts, and of the ſubſtance of the heart.

13. *a.* THE ſtrong contractions of the ventricles drives blood into the arterial ſyſtem. By expanſion of the arteries, as well as by the progreſſive enlargement of their capacities collectively taken, the force of the impetus is diminiſhed in remote parts, and the exhalants and ſecreting veſſels perform their functions uninterruptedly.

b. Do the arteries take twice the time of the ventricles to perform their ſyſtole, and is the current hereby rendered continual in remote parts, as in the exhalants and ſecreting veſſels, and without ſenſible pulſation as in the veins.

c. Synchronous with the contraction of the arteries is that of the cardiac ſinuſes, which, while they are continually open on the venous ſide, whereby regurgitation into the veins is ſometimes produced, (or at leaſt accumulation happens in them,)

The coronary vein opening into the right ſinus, is furniſhed at its mouth with a valve, with this deſign, perhaps, that it may not in any caſe receive greater diſtenſion, than what can be produced by the interruption of its own ſtream, diſtenſion which might be hurtful to the motions of the heart.

Neceſſity for venous ſinuſes in the head.

14. *a.* ALL the proviſion, of ſinuſes and dilatable veins at the heart, does not appear to be ſufficient to guard ſo delicate a part as the brain from the effect of reaction, by interruption of the venous current at the heart.

b. For this reaſon it ſeems to be, that venous ſinuſes are formed in the head to ſuch an extent as to contain, it is ſuppoſed, one tenth of the whole maſs of blood in the body. Into theſe the veins,

ariſing from the brain, pour their contents, in rather a retrograde direction: and this may prove another guard againſt the effects of reaction, from interruption of the venous current at the right ſide of the heart.

15. The neceſſity for theſe ſinuſes may appear, when we conſider that the preſſure on the brain is continually changing.

A. a. The contents of the cranium ſwell gently under ordinary expiration, and are diminiſhed under inſpiration.

b. This may be a convenient mode of keeping up the inteſtine motion, neceſſary to living parts, which could not ſo well have been effected here, by ſtrong circulation, as in muſcular parts of the body.

c. But under long and deep expiration, a turgidity thro' compreſſion of the brain, as well as an anxiety in the thorax, takes place, which is only to be relieved by long and deep inſpiration.

d. Are not the compreſſion and anxiety on ſuch occaſions produced by accumulation in the venous ſinuſes, thro' obſtruction of the paſſage of the blood in the pulmonary artery, retrograding to the head,

e. (While the motions of the heart may in fact be impeded) by ſuch conſtriction of the air cells in the lungs?

f. And is not the relief afforded on ſuch occaſions owing as much to the ſimple mechanical enlargement of veſſels and parts, by diſtenſion of the reſpiratory organs, thro' inſpiration, as to the neceſſary ſupply of freſh air?

g. While the diſorder, created by too long a retention of inſpired air ſeems entirely owing to the want of the neceſſary chemical change of the blood in the lungs.

h. Hereby the vital powers of the heart flag; and while its left ventricle, in particular, not receiving, from the now undecarbonated ſtream of blood, its wonted ſtimulus, fails to propel it with its uſual force.

i. The blood in the remote and minute arteries, and in the ſtill more remote part of the vital ſtream throughout the venous ſyſtem, having already received the impulſe of

previous effective ſyſtoles and conſequently continuing its courſe to the heart, an accumulation may at length take place retrograding from the right ſide of the heart (perhaps from the mouth of the left ventricle, as the right ventricle does not require decarbonated blood to ſtimulate it to the neceſſary contraction) by which the venous ſinuſes, at firſt diminiſhed by ſtrong inſpiration, may become ſwollen.

k. And thus, at laſt, compreſſion of the brain, with blackneſs of the face, *tinnitus aurium*, &c. not to be relieved but by complete expiration of the now lethal air in the lungs, and ſucceeding reſpirations of freſh air.

B. a. The contents of the cranium alſo ſwell, and the pulſe quickens, under watching and exerciſe, till at length the refection of ſleep is ſolicited.

b. If there be congeſtion of blood on the right ſide of the heart, the neceſſity of deep inſpiration is yielded to, and marked, by a ſigh or a yawn.

c. The organs of the ſenſes and muſcles of voluntary motion relax.

d. There is no longer that compreſſion on the ſanguiferous ſyſtem of veſſels on the trunk and in the limbs;

e. The blood conſequently retires from the head,

f. And the brain loſes the compreſſion neceſſary to a ſtate of wakefulneſs.

g. The organs of the vital and natural functions participate in the relaxation and perform their actions with diminiſhed force,

h. Till the organs of the animal powers having acquired new tone or excitability, thoſe of the vital and natural powers ſympathiſe with them,

i. A larger quantity of blood is determined to the head,

k. And the whole man awakes into renewed life and animation.

16. *Different cauſes of motion.*

A. a. To the ventricles belongs the duty of propelling the blood to the different parts of the body, and in a certain

degree back again; for other parts beſides the ventricles, and other powers beſides the contractile ones may contribute thereto.

Vital powers.

b. If the contractile powers as the moſt eminent teſts of life, or rather, if the irritability of phyſiologiſts as diſtinguiſhed from contractility (can a diſtinct line be drawn between theſe two different affections of vital power or effects of life?) may be here peculiarly diſtinguiſhed by the name of vital, it may be ſaid that chemical and mechanical cauſes contribute with the vital powers to effect the circulation of the blood, as well as the changes it has to undergo in its courſe.

c. Theſe vital, or for diſtinction, the muſcular, powers, eminently prevail through the whole arterial ſyſtem. The large arteries are dilated and receive an accumulation of blood; upon which they contract when the ſyſtole of the ventricles is completed. Their valves at the heart prevent the retrogreſſion of the blood. It is driven along by muſcular contraction of the arteries; the dilatation and ſucceeding contraction being propelled throughout the arterial ſyſtems, after every ſyſtole of the heart.

d. Hence the pulſations in the parts of the body, remote from the heart, are later than in the arterial trunks. To produce ſynchronous pulſations (or rather jactations, for there would be no ſenſible pulſe) would require arteries incapable of diſtenſion and a contained fluid perfectly non-elaſtic.

e. The muſcular powers of the veins appear to be but ſmall, and muſcular fibres ſeem only diſcoverable, in their extremities more particularly in the great trunks at the heart. What there may be of muſcular fibre in the minute branches, or rather roots, of the veins, as they ariſe from the arteries, may be conſidered, as a continuation of the arterial muſcular coat, which ceaſes where the progreſſive pulſatory arterial impulſe no longer has place.

Venous current aided by lateral muſcular preſſure.

B. a. Besides the lateral preſſure on veins from arterial pulſation, there is a more forcible mechanical preſſure on ſome of them, produced by the action of ſurrounding

muſcles. Theſe veins have not only the force of the eſtabliſhed current of the blood, but valves alſo to oppoſe its retrogreſſion.

b. If the force of the preſſure be equally employed in impeding the coming, as in forwarding the going, blood at the place of preſſure, the accelerating effect goes on progreſſively to and through the heart, (*c.*) while the interruption though continued at the place of preſſure, is only partially felt in the current, which now flows more fully through the cutaneous veins, preventing retrogreſſion like unto, even more effectually than, the ſinuſes at the head and heart,

d. The cutaneous veins anaſtomoſing, or having frequent communication, with the internal ones, whereby they alſo become diſtended, when the blood is expanded ſimply by heat.

Filtration, lymphaticks, capillary attraction.

C. Besides the ſanguiferous veins and ſecreting veſſels, the ſerous ones alſo ariſe from the arteries.

a. Their diameters, it is ſaid, are too ſmall to admit the cruor: they receive only the thin part of the blood, which is diffuſed throughout the whole body, and moiſtens all internal ſurfaces.

b. What remains of this (changed in its nature, accordingly as it has been diſtributed to different parts of the body) is taken up by the lymphaticks.

c. It is ſuppoſed that capillary attraction contributes to this abſorption:

d. That it is by the contractile power (as diſtinct from irritability) of the lymphaticks as well as of cellular membrane, which is like a ſpungy reſervoir every where diffuſed, that it is principally forwarded towards the thoracic duct, where, together with whatever multifarious fluid is received from the ſurrounding atmoſphere, &c. by the cutaneous abſorbents, it mingles with the chyle, itſelf compoſed of the nutritive part of the aliment, of ſaliva, of gaſtric, pancreatic, enteric and bilious fluids, &c.

e. It ſeems difficult to conceive how this can be effected without diſtinct irritability, or diſtinct alternation of contraction and dilatation, in the abſorbing veſſels, unleſs the force of

the *vis a tergo* be ſuppoſed to be continued from the arteries into the lymphaticks, which muſt appear impoſſible when we conſider, that the roots of the abſorbents terminate generally in cellular membrane:

f. And this cannot happen to the chyle, which is continually flowing from the alimentary canal, nor to the fluids abſorbed at the external ſurface of the body; at leaſt at the extremities of theſe veſſels where the abſorption firſt begins.

D. a. To capillary attraction, has been referred the entrance of the blood into minute ſanguiferous veſſels.

b. But what can capillary attraction alone effect, in one caſe or the other, when the veſſels are continually growing wider (ſingly) from the extremities of their roots?

Again, if the filling of the exhalants were a mere affair of filtration, what prevents the red globules, if round and of a gelatinous ſubſtance, from ſtopping up the orifices of theſe veſſels? or are they only gelatinous when extravaſated and dead? and do they then only become ſpherical in yielding to the common law of aggregative attraction which determines all bodies not under the influence of chryſtalliſation or vitality into ſpherical figures? If ſo then may we ſuppoſe, that their containing veſicles endued with life give them a determinate form (as has been imagined ſextuple, annular or lenticular, &c.) not correſponding with that of the mouths of the ſerous veſſels, whereby the ſerum may enter while the cruroric particles are, if I may ſo expreſs it, jammed in the round orifices---and, while all the other organiſed parts of the body are, through their mutual connexions with, and mutual actions upon each other, (every where giving and receiving, or tranſmitting fluids) tending every where towards ſpherical, cylindric, and conic forms, through dilatation from their contained fluids, theſe diſtinctly organiſed bodies, for ſuch we muſt account every veſicular ſubſtance, theſe inſulated living forms, removed from all ſuch influence, and ſwimming in a yielding fluid, may bear their native figure ſo long as they continue inſulated; and may change it only perhaps when taking to themſelves the candidates for life and organiſation, the beginning fibres of the blood, the coagulable lymph, they, thus aſſociated, attach themſelves to connected parts; or when attaching themſelves, without ſuch aſſociation, they themſelves are united to connected parts, their places being ſupplied perhaps by the fibrous part putting on the cruoric form and nature; or when diſſolved, they, by a further elaboration, whether in the nervous ſyſtem, or in whatever other way, conſtantly repair the continually conſuming ſubstance of all connected parts.

But if their ſpherical figure exiſt, only, in living or recently drawn blood, and if this figure be changed in permeating veſſels of very ſmall diameter; then may it yet more earneſtly be aſked, what prevents their ſtopping up the ſerous veſſels?

E. a. Is it becauſe the decarbonated blood cannot obtain charcoal in theſe veſſels?

b. And is the cruor particularly, on this account; drawn forwards by chemical attraction, along the venous ſyſtem? If this be the caſe,

c. Then, excluſively of the impetus given at the heart (which, notwithſtanding the difference there may be between dead and living veſſels, we muſt believe to be the grand proximate cauſe of the circulation, when we conſider, that by injecting after death, by an artery, the injec

tion may be puſhed round to the heart, and microſcopic veſſels be filled with it at the ſame time,)

d. The blood muſt naturally tend forwards; for its power of abſorbing carbone diminiſhing as it proceeds, ariſes from its receiving this element, as it paſſes along, from ſurrounding parts. It therefore must be continually attracted forwards to the part where the carbone abounds more than it ever can do, where the newly decarbonated ſtream is continualy pouring along the arterial ſyſtem.

e. But the human body is not ſufficiently ſtrong to undergo chemical proceſs ſo rapid, intenſe, and extended. We might about as rationally ſuppoſe, that the lungs were a furnace, the heart a boiling kettle; and, that the ſyſtole of the ventricles was an exploſion from ebullition, and their diaſtole a reception of freſh fluid, to be in its turn driven forwards, when ſufficiently heated.

f. If the current of blood were capable of being dragged forward by chemical attraction, as above mentioned, then might we ſee another cauſe for its quick motion in the *cavæ*, and for its ſlow motion in the *vena portæ*, beſides the ſtructure or dimenſions of theſe parts. We might ſuppoſe an indiſpoſition in the blood (already ſo fully charged with carbone from the abdominal viſcera) to enter the liver, where carbone ſo much abounds; unleſs indeed we ſhould ſuppoſe that it would be drawn thither to get rid of carbone in this elaboratory of bile, a fluid ſo highly charged with this element: and, on the other hand, we might ſuppoſe a preſſure forwards of the blood in the *cavæ* to the right ſide of the heart, through which alone it can find a paſſage to the air cells of the lungs, where there is a continual ſupply of matter, to which the carbone is more affinitive, than it is to the blood itſelf.

But, though it ſeem not poſſible that chemical attraction ſhould exiſt in the body, powerful enough to produce progreſſive motion of the blood in this manner; yet it is probable, that in its inteſtine motions, all its changes, in every organ and part, are immediately under chemical influence. And, as in blood drawn from the body, the effects of chemical attraction, as well as of thoſe of gravitation, are noticeable; thoſe in the formation of the craſſamentum, theſe in its ſeeking the bottom of the veſſel; ſo the affinitive attraction of cruoric globules and lymphatic fibres, to each other, may perhaps be ſufficiently ſtrong, to prevent them from deeply entering any other veſſels, than thoſe which are large enough to tranſmit them, or than thoſe where their preſence may be required to become attached to connected parts, and to which they become connected, not perhaps without the aid of affinitive attraction and of that of coheſion (if there be any difference between the two) combined, as in every function of organised parts, with the inexplicable principles of life.

Vital appetencies and revulſions.

F. a. Capillary attraction, or the attraction of coheſion, alone, ſeem to have a greater tendency to arreſt fluids in their cavities than to give them progreſſive motion.

b. And chemical attractions are conſtantly modified in organiſed bodies by the inexplicable principle of life.

c. The ſecretion in the different organs, not to be imitated by any art; and the progreſſive motions of fluids in the ab-

ſorbents, not by any mechaniſm, may be referable to certain appetencies and revulſions in the parts immediately concerned, which may, for any thing we know, have been originally felt in the embryo, when it, as it were, vegetated in the womb, (its roots being without its body,) with a ſenſibility perhaps as obtuſe as that poſſeſſed by vegetable creatures; and, through the exerciſe of enlarged capacities of ſenſibility and intellectuality after birth, the perception of theſe moſt minute ſenſations may have been loſt; as we are not now otherwiſe ſenſible of them than in their general effect; or rather, we are only conſcious of their general effect, while they themſelves, the cauſes of this effect, are undetectable.

d. It has been thought, that ſimilar appetencies in veins and revulſions in the heart and arteries may alſo produce, with the other different changes of the blood, its ſimple circulatory motion through the veins, heart, and arteries.

e, But if we may thus carry into the organs of the vital and natural functions, the idea of will, however latent, muſt we not alſo ſuppoſe, that, like other parts evidently ſubject to the will, they muſt experience the changes, not only of action and reſt, but alſo of watchfulneſs and ſleep?

Adopting ſuch idea then, all the moving fibres throughout the ſyſtem, where vital and natural functions are going on, are, in their relaxations, falling aſleep, and letting others fall aſleep; in their diſtenſions they are rouſed by their neighbouring fibres already awake and at work; and in their contractions, they are themſelves at work and waking other fibres, by throwing upon them the burden of driving fluid along, till they take another nap.

In this way the fibres of the ventricles may, as working harder, take longer naps than thoſe of the cardiac ſinuſes, or the arteries; and if the venous trunks, without working ſo hard, ſeem to take naps as long as the ventricles, not only may it be apologiſed for them, that the poor things are weak, and not ſo well able to hold out; but, it may alſo be added, that they do not ſleep ſo ſound. For, no ſooner have they done their little work, performed their faint contractions, during the diaſtole of the ſinuſes, and become compoſed to ſleep, than *bang* comes the blood, ſent ſome time before, from the arteries, preſently begins to wake them, and reſts not till they be ſufficiently rouſed, or ſtretched, to renew their contractions.

Thus, as in all juſt and well regulated aſſociations, the rewards or comforts afforded to individual parts, are proportioned to their toils for the good of the whole, and ſuited to their capacities for duties and enjoyments.

f. If the idea of alternately ſleeping and acting, do not embrace the notion of appetency and revulſion, it is only changing the terms a little, and, for greater correctneſs, we may then ſay, however groſs the language may ſeem, that the veſſels and parts of veſſels, alternately drink and ſpew; that in falling aſleep they begin to drink, not by diſtinct deglutition, but, by enlargement of cavity, through a gently relaxing fibre; that the neighbouring parts, already awake, and ſpewing into them their drink, cram them ſo full, that they have, in their turn, to ſpew into other parts, with ſuch force as to produce an irritating diſtenſion with nauſea, which makes theſe ſpew forwards their contents, in order to ſleep and drink again: and thus, alas, ſhould the deleterious debauch of the drunkard or glutton, bet-

ter than juſtly regulated aſſociations of men, bear compariſon with the effecting of vital functions. But the diſcharge is not a revomition, but a propulſion. Revulſion, we may ſuppoſe, does not even take place in the ſyſtem, but from morbid influence, or where by ſeaſonable, even retrograding or repulſing, conſtriction, as in well regulated aſſociations of men, that which would be hurtful is ſhut out, or even repelled. In cloyed voluptuaries, revulſion is a healthy effort of the ſyſtem, to reſiſt the violence which they offer to it, to throw off the load with which they oppreſs it.

Origin of the contractile powers in the arteries and cardiac ſinuſes.

WHILE the blood ſeems to ſtimulate the ventricles, not only chemically, but alſo ſometimes mechanically from diſtenſion, to a vital contraction of their fibres, may we not conſider, even without reckoning upon the mechanical ſtimulus, the contractile power of the arteries as well as of the ſinuſes, as growing (if we may attempt to find a beginning) out of their connexion with the ventricles.

17. *a.* To the ventricles belongs the duty of propelling the blood to the different parts of the body, and in a certain degree back again.

b. It is not a mere circulation of this fluid that is wanted. It muſt undergo changes in its courſe—it muſt loſe parts of itſelf—it muſt gain acceſſions of new matter.

c. For theſe purpoſes, its degrees of velocity muſt vary. It muſt not be hurried along all the way by pulſations. Where, and how, is a reſting place, or rather a ſlackening pace, to be obtained for it?

d. The ventricles contract with uncontroulable vehemence; the arteries receive their contents and are dilated.

e. The dilatation is propelled to the remote and minute branches with a force and velocity which diminiſh as it advances, becauſe the branches do not diminiſh in capacity, in proportion as they increaſe in number, as well as becauſe of their yielding to diſtenſion, from the ſyſtole of the heart.

f. If we except the pulmonary veſſels, the venous ſyſtem is more capacious than the arterial. (12. *c.*)

g. In it the blood runs without ſenſible pulſation.

h. It cannot, however, keep a ſteady and unremitting motion into the ventricles.

i. By the decreaſe of capacity in the veins, collectively, its rapidity increaſes, as it approaches towards the heart;

k. And, owing to its interruption at the mouths of the ventricles, the conducting veſſels are dilated.

l. They contract, when, by the opening of the valves of the ventricles, the interruption is taken off.

m. And, to this, may we not aſcribe the formation of the ſinuſes, which would have been equally found at the commencement of the arteries, if there had not been a free paſſage in them, an invitation (through a progreſſively relaxing fibre) to the large arteries, to throw their blood upon the ſmaller branches, thus dividing with them, or diffuſing to the remote and minute arteries, the effect of the grand impetus of the ſyſtole of the ventricles?

Neceſſity for the ventricles ſynchroniſing, from the ſtructure of the heart.

18. *a.* If the heart could have exiſted without ſinuſes, and its ventricles of conſequence had been obliged to alternate in their motions, the contiguous fibres of the two ventricles, which, interſecting each other, contribute mutually to each other's aid, in the ſyſtole of the heart, would in that caſe have oppoſed each other's contractions. The ſtructure of this vital organ must have been changed; or, inſtead of one double heart, there must have been two ſingle ones.

b. The large ſanguiferous veſſels of the pulmonary ſyſtem and thoſe of the general ſyſtem might have diſturbed each other's motions; and if this had happened, the effects muſt have been felt in the remote branches.

c. Reſpiration might have been disturbed.

Neceſſity for ſynchroniſing veſſels on the birth.

19. But, if the ventricles of the heart had alternated in their motions, even furniſhed as they are with auricles and dilating arteries, what had been the lot of the children of the firſt parents of the human kind?

a. *Naſcentes moriuntur* had been literally true. Each in-

fant had gaſped out its life, on its entrance into the world.

b. All that admirable œconomy in the ſtructure of the heart which fits the animal, ſucceſſively, for its foetal and enlarged ſtate of being, could not have applied to a heart, whoſe ventricles alternated in their motions.

c. For, if a *foramen ovale* had been open, to have taken off the ſame quantity of blood, as is diverted in this way from entering the right ventricle, the further diverſion from the yet unfolded lungs, through a *canalis arterioſus*, to be effected by contraction of the right ventricle, could not have taken place if the ventricles had alternated; becauſe the time of dilatation in the *canalis arterioſus* would been the time of contraction in the *aorta*.

d. Conſequently, the right ventricle failing to bear a part, in propelling blood to the parent, the *foramen* muſt have enlarged, the *canalis* cloſed; the powers and dimenſions of the left ventricle muſt have increaſed, and thoſe of the right ventricle diminiſhed.

e. When the creature was born, the left ventricle muſt have thrown the blood with ſuch impetuoſity through the greater ſyſtem, that, arrived at the right ventricle, ſtriving with ineffectual powers to unfold the pulmonary ſyſtem of blood veſſels, it would have overwhelmed it, while the left ventricle would have been exhauſted, (if the *foramen ovale* could have cloſed);

f. Unleſs indeed, this itſelf had been more ſuddenly and effectually overwhelmed, by the circulation through the *placenta* and *ductus venoſus* being ſtopped,

g. Which is always, perhaps, the proximate cauſe of the immediate death of the fœtus, on the ſtoppage of the circulation, through the umbilical cord, before its breathing --- viz. the deadly force of the reaction, thrown upon the heart;

h. But which in caſe of happy birth, no longer deadly, is principally employed by the right ventricle, upon the lungs, to give them their required enlargement;

i. While, the force of the current in the *aorta*

being thus, for a moment, diminiſhed on the one hand; and,

k. On the other, the no longer crumpled-up animal getting room for the enlargement of all its veſſels and viſcera,

l. The vital ſtream, in greater quantity, makes its way alſo through the greater ſyſtem, diſtending its veſſels for the reception and tranſmiſſion of the whole vital ſtream, and,

m. Leaving thoſe veſſels that were intended to be ſanguiferous, only during the foetal ſtate, to gradually aſſume a ligamentous nature, ſuited to the new mode of being of the animal.

n. After a ſlight effort to breathe, the homuncule, with alternating ventricles, would have expired, ſuffocated by the unequal diſtribution of its own fluids or from the unfit diſtribution of power in its vital organs: for

o We can hardly ſuppoſe, if the *foramen ovale* had been kept open, that the fœtal life, ſometimes afforded to the infant through the umbilical cord, for a ſhort while after birth, ere it yet breathe, and even after breathing, could have continued, till it had ſo gradually died away, that by the left ventricle loſing its exceſs of power, and by the right one's receiving this loſt force, the neceſſary equilibrium, or due diſtribution of muſcular energy, had been effected in this vital organ;

p. While the veſſels of the organs of reſpiration were gradually, inſtead of quickly, unfolded, and fitted to perform functions, eſſential to the exiſtence of the animal, when ſeparated from the parent.

The cavity of the thorax is expanded, and the lungs are conſequently inflated with a force and velocity almoſt convulſive, by contraction of the diaphragm and other muſcles, on the child's coming into the cold atmoſphere, as are thoſe of the adult on his plunging into cold water. The inflation in both caſes is followed by quick expiration, and by ſucceſſions of gradually tranquilliſing reſpirations, as the parts become inured to, or leſs ſenſible of, the ſtimulus of cold.

While the *ductus arterioſus* continues open after birth, the power of the right ventricle may be in part employed, together with that of the left ventricle, in expanding the veſſels of the general ſyſtem; but when thoſe of the pulmonary ſyſtem

are ſufficiently enlarged, the *ductus arterioſus* muſt cloſe, equally from the *vis a tergo* of its current being diverted into the pulmonary ſyſtem, and from the veſſels of the greater ſyſtem being filled by the left ventricle.

Thus, while the functions of theſe vital parts are ſo materially, ſo ſuddenly, and ſo forcibly changed, there ſeems to be an ample proviſion made, to prevent mortal effects from too ſudden violence, in leaving open, at the ſame moment, the whole range of the two arterial ſyſtems (through the medium of a ſlowly contracting *ductus arterioſus*) to the ſyſtole of the right ventricle, which might have been too ſtrong if it had been, at once and totally, thrown upon the lungs.

In proportion as the *ductus arterioſus* cloſes, the quantity of blood thrown into the left ſinus is increaſed, hence leſs of the blood from the *cavæ* is admitted to paſs through the *foramen ovale*, and more of it is thrown into the lungs---every drop of it, ſo diverted through the lungs, gives, on its arrival in the left ſinus, additional force to the preſſure an the valve of the *foramen ovale*.

The tendency of the blood, from the *cavæ* (*cava inferior*?) to paſs through the *foramen ovale* continually diminiſhing, by the unfolding of the lungs, at leaſt from the moment of the cloſing of the *ductus arterioſus*; and the reſiſtance made to its paſſing through the *foramen ovale* continually increaſing from the yet earlier moment that an increaſed quantity of blood arrives in the left ſinus from the firſt unfolding of the lungs,---the *foramen ovale* is ſoon completely ſtopt, and the circulation, ſuited to the being of a breathing animal, is fully eſtabliſhed.

But if the ventricles had alternated, the ſinuſes muſt alſo have alternated; and the immenſe *foramen ovale*, hereby

occaſioned, muſt always have continued open; for the right ſinus would have always had, on contraction, a yielding left ſinus ready to receive blood in the old fœtal way; ſo that, if the left ventricle could have withſtood the firſt ſhock, from the reaction on the ſtoppage of the arterial currents in the umbilical cord; and, if the blood from the *cavæ*, by going directly through the immenſe *foramen ovale*, had not overwhelmed the right ventricle, the ſhort-breathed animal, ſo affected as the offſpring of warm-blooded parents, labouring in vain for a ſupply of air, if its life had been continued, muſt have been changed.

In its nature it could not have ranked among warm-blooded animals. It might have claſſed with the amphibia, and gone down with the tortoiſe, into the coral groves of the deep, both being almoſt equally fitted to have the ſhort circulation effected; the quadruped, by the communication between its ventricles, (5. *b.*) the other by that between its cardiac ſinuſes. There, if it had retained any of its native ſuperiority of capacity for doing miſchief, as well as good, it might have committed depredations in another way; might have contrived other means of enſlaving and deſtroying its own ſpecies and other creatures; might ſtill have been a *ſportſman* and purſued its *game* in both elements; might ſtill, as at preſent, and more extenſively, have drawn fiſh from their watry beds, and dragged land animals thither; it might have ſuffocated the tribes of cetaceous fiſh, in their own element, and contemplated, in the watry deep, their agonies with impunity; but when *in at ſuch a death*, it could not have celebrated its triumph and barbarous joy, by ſhouts and the ſound of the horn. What a pity that the ladies who wear pearls, and the merchants who ſupply them, cannot find ſome ſuch *luſus naturæ*, as a man with alternating ſinuſes at the heart! Such a ſubject ſent to the Perſian Gulph, or other pearl fiſhery, might reſcue divers there, victims to avarice and vanity, (commonly black ſlaves,) from having their lives harraſsed and worn down, when not more readily put an end to by ſuffocation, through their unnatural employ!

II. ON INORDINATE MOTIONS OF THE HEART.

HOW comes it that violent exerciſe produces a palpitation in the heart?

Cauſes of palpitation.

20. *a.* THE muſcular preſſure on the veins quickens the motion of the contained fluid. Their valves, which are moſt numerous where they are

most expoſed to muſcular preſſure, utterly prevent its retrogreſſion. It is propelled to the heart with augmented force or accelerated velocity.

b. It is difficult to conceive how quickened motion of the blood can produce palpitation in the heart, if all the motions of this organ be alike quickened. Muſt there not an irregularity, as well as a rapidity in its motions, have been produced?

The balance may have been loſt, either in point of time or of force, between the contractions of the ſinuſes and ventricles.

c. While the ſinuſes, by their motions alternating with thoſe of the ventricles, prevent the ſtrong contractions and extenſive dilatations of theſe, from producing a hurtful agitation, they ſeem to hold an intermediary ſtation between the veins and the ventricles, not only in reſpect of place, but alſo in their uſe and nature.

d. By their being unfurniſhed with valves, they admit the blood, even during contraction, to paſs through them to the ventricles, and thus prevent, during the contraction, too great and too ſudden an accumulation in the vein. (10. *b.*) (12. *b. d.*) (13. *c.*)

e. They ſeem, then, peculiarly to afford aid or relief to the veins, preventing retrograde pulſation.

f. May it not be from their accommodating themſelves to the neceſſities of the veins, or from their yielding to the increaſed velocity, or accumulation of blood in them, that ſo ſenſible an agitation is produced by muſcular exertion, as in the caſe of running up and down ſtairs? (3. *a. a.*)

Balance loſt in point of force.

21. *a.* From the quickened motion of the blood in the veins, an inordinate accumulation commences in the venous trunks at the heart; the ſinuſes yield; their contractions are not ſo complete; they approach more, in their nature, the paſſive condition of the veins, than they did when, undiſturbed, their contractions and dilatations were of ſuch an extent, that they ſo balanced with thoſe of the ventricles, that the motions of the heart were not diſcernible to the ſight, the touch, nor to the preſſure of the hand on the thorax, (2. *b.*)

b. While the energetic and uncontroulable ventricles (more eſpecially perhaps the left one, if the mouth of the *aorta* be covered by one of the valves of the ventricle during its diaſtole?) make full contractions and dilatations.

c. In this caſe the balance is loſt between the ſinuſes and the ventricles in point of force.

Balance loſt in point of time.

22. *a.* But if the ſinuſes make proportionably ſtronger contractions under palpitation, as produced by muſcular exertions, they may fill too quickly; not indeed

(13. *a.*) In leſs time, than that of the ſyſtole of the ventricles, when their valves are once ſhut, when their contraction has actually commenced; but the ſinuſes may ſwell and fill too ſoon, may be ready to burſt, at that interval, when the fibres of the ventricles (pertinaciouſly retaining the property of ſtrong muſcle, (13. *a.*) the ſlowly relaxing fibres not ſo eaſily yielding to be driven, to be ſtretched, as the weaker ſinuſes) are paſſing from a ſtate of relaxation to that of contraction.

b. In this caſe, the balance is loſt in point of time; and the ſyſtolic ſtroke of the ventricle is not balanced by the diaſtole of the ſinus. The contraction and dilatation are not ſufficiently ſynchronous.

In tranquil circulation, the blood is perhaps principally drawn into the ventricles, by their ſpontaneouſly relaxing fibres; while, in hurried circulation, it is driven into them, by the ſinuſes being ſtrained to unuſual contractions.

c. From the ſinuſes filling too ſoon, we might, at firſt view, ſuppoſe, that the laſt part of the ſyſtole muſt give the ſhock, which produces the ſenſation of palpitation, by its tendency to produce a vacuum. The ſhock, however, would rather produce a general ſhake of the thorax or its contents.

d. But the ſenſation is that of a local ſtroke, as of the apex of the heart knocking againſt the ribs. This is attributed, to the venous torrent preſſing in forwards to the heart, and to the re-action, from the exploſion of the blood from the heart into the arteries:

e. And if the ſinuſes fill too quickly, if they yield alſo and an accumulation conſequently takes place in them, retrograding at the ſame time into the venous trunks; then, may not a ſort of general, confuſed or indiſtinct, retrograding contraction upon ſuch accumulation take place, inſtead of diſtinct contraction of ſinus, alternating with that of ventricle and large vein, and ſynchroniſing with that of artery; and, a ſucceed-

ing general, confuſed or indiſtinct tumefaction, retrograding from the mouths of the ventricles into the veins, inſtead of contractions of vein, however faint, alternating with thoſe of ſinus and artery, and ſynchroniſing with thoſe of the ventricles? hereby the moment when the large arteries ſwell is no longer the time when the large veins may contract. (9. *a.*) Conſequently there is not room for the expanſion of the arteries, or, there is a reſiſtance to it; by which, the heart is thrown forward by the ſyſtole.

In other words, ſack is no longer duly aſſociated with ſack in their alternations, nor tube with tube; but the ſinuſes and veins being violently dilated and oppreſſed, and, conſequently, incapable of performing their actions diſtinctly, the heart is continually puſhed forward during the whole pulſe, and particularly ſo when, by the tumid ſtate of the large veins, the arteries have not room to become expanded with ſufficient velocity for the reception of the blood on the ſyſtole of the ventricles, and the apex of the heart is conſequently driven againſt the ribs.

f. If there were not, while the ſinuſes fill thus quickly, accumulation in the large veins, impeding the expanſion of the large arteries, on the ſyſtole of the ventricles, this, inſtead of driving the apex of the heart againſt the ribs would on the contrary, draw it from them. (4.)

Defence of pulmonary blood veſſels from diſtenſion.

a. Does the right ventricle, from its not being cloſed at the mouth of the pulmonary artery, at the time of the diaſtole, let the exceſs of blood paſs through it,

b. And, thus not ſo readily become diſtended to exceſs as the left ventricle? and is it to exceſs of force in the left that we ought to attribute, at leaſt the commencement of palpitation?

c. This œconomy (capacity of opening in the mouth of the pulmonary artery: for, from the ſlowneſs of dilatation of the ventricles, the ſyſtole of the pulmonary arterial trunk may perhaps be completed a moment before that of the ventricles commences) is perhaps eſtabliſhed ſimply to moderate the arterial impulſe through the lungs, which have to receive it in every ſtate of their dilataiton and contraction under reſpiration.

d. While the large ſinus at the left ventricle, capable of extenſive dilatation, may hereby more effectually prevent accumulation in the pulmonary veins.

e. Thus, on one ſide the lungs ſeem to be guarded from exceſs of force in the ventricles, on the other, from exceſs of quantity in the veins.

Palpitation from diſturbed circulation.

A. a If on the right and weaker ſide of the heart, which has only to forward the blood through the pulmonary ſyſtem, we have a ventricle permitting blood to paſs through it during its diaſtole; (23.)

b. And on the left and ſtronger ſide, which has to propel it through the greater ſyſtem, a capacious ſinus more ſtrongly muſcular than that on the right, and conſequently better able to keep up the balance of power, and of time alſo, (if after all, there be any fitneſs in the idea of the balance being kept up or loſt between the alternating cavities of theheart under different circumſtances) againſt the energetic left ventricle, then may we expect in the healthy heart, ſhaken only by exceſs of exerciſe, that the right ventricles will contribute as early as the left to produce the ſenſation of palpitation.

c. The ventricles muſt act ſympathetically. In time their motions muſt be ſynchronous; their increaſe of force proportionate to their ſtrength reſpectively.

B. a. Do not the ſame effects take place, and in the ſame way, as by violent exerciſe, when the pulſe is quickened to exceſs by violent affections of the mind, if, as is thought, theſe act upon the arterial ſyſtem through the nerves? Or rather by ſuch ſudden and greater contraction of arteries, and their conſequently greater and quicker expanſion, the blood ſhould be drawn, or as it were pumped, from the heart, as by muſcular exertion it is driven to it: and in ſuch caſe if it were poſſible to interrupt or deſtroy the cloſe ſympathy between the ventricles, (ſympathy diffuſed perhaps throughout the two arterial ſyſtems) we might expect perhaps the agitation to begin on the left ſide of the heart; as whatever effect may by ſuch mental affections be ſo produced in the whole greater ſyſtem, it muſt immediately affect the left ventricle; while the pulmonary arteries can only ſo affect the right ventricle.

b. However this might be, on the firſt commencement of the agitation, the apex of the heart, muſt rather retire from the ribs than ſtrike them on the ſyſtole of the heart, affection which becomes reverſed, however, immediately on the quickened blood getting round into the venous trunks.

c. But have we not reaſon to think that the commotion produced in the circulation by mental affections, is effected through the medium of the organs of the animal functions? Is there any violent or earnest affection of the mind which does not ſenſibly affect the organs of voluntary motion; the invigorating paſſions, and even the moſt debilitating one (fear) in its firſt effect, (fright) producing a conſtriction in their muſcular fibres ſufficient to throw the blood with force on the heart, as in the caſe of violent exerciſe, and to make, perhaps, if it were poſſible, the palpitation begin on the right ſide of the heart?

C. a. Do not the ſame effects take place when the pulſe is quickened to exceſs by pain, and by heat, &c. as when it is hurried by exerciſe?

b. And is not the caſe the ſame when it is quickened by ſtimulants taken inwardly, if, as perhaps always is the caſe, the effect be produced (be-

fore, or even without that, ſtimulant matter enter the blood) through the medium of the nerves, thoſe of the organs of the animal functions ſympathiſing with thoſe of the ſtomach; and thus paſſing to vital organs the ſtimulating effects which begun in an organ (leſs delicate) of the natural functions.

c. This kind of palpitation is a throbbing which reſt, ſerenity, eaſe and temperance remove.

D. a. The ſame effects are often produced by certain diſeaſes of the pyrexial claſs, of which pain, &c. are parts.

b. Diſeaſes of other claſſes may produce pyrexial ſymptoms; may affect the circulation of the blood in the ſame way.

c. In all theſe caſes it is evident, that the malady, which occaſions the morbid irregularity in the circulation, muſt be removed, in order to produce a cure; and in this there muſt be effected a change in the general ſyſtem.

Palpitations, ſtrictly ſo called.

ALL the inſtances of palpitation, yet mentioned, may be conſidered as throbbings produced by diſturbed circulation.

25. *a.* There are others which ſeem to be rather the cauſe, than the effect, of diſturbed circulation, and which are perhaps more ſtrictly palpitations, than thoſe already mentioned.

b. Under theſe the pulſe may be violent, weak, unequal, intermittent.

c. Such are thoſe which ariſe from malconformation, or diſeaſes in the heart or its veſſels, by conſtrictions, amplifications, polypi, oſſifications, &c.

d. Under theſe the balance may be loſt between the ventricles themſelves, as well as between the ventricles and ſinuſes.

e. May both theſe kinds of palpitation be alſo produced, even mechanically, by impeded reſpiration, by diſtenſion of ſtomach, by derangement of other viſcera?

f. Palpitations, ſtrictly ſo called, appear to be produced alſo by nervous affections, where mind is not concerned, as from weakneſs alone, from ſpaſmodic affections, if indeed the heart be not always acted upon in theſe caſes through the organs of the animal functions.

Perhaps ſpaſm does not ever take place in parts not ſubjected to the will, which is probably the caſe with the ſtomach, and the whole alimentary canal, with the urinary bladder and viſcera in general, as well as with the heart, and all the veſſels concerned in the circulation.

Are not rumination and all voluntary eructations effected, entirely, by ſuch voluntary diſpoſition of the diaphragm and the muſcles of the trunk, as by the law of determination forces air or aliment from the ſtomach through the cardia, which ſtimulates the oeſophagus to the neceſſary inverted motion? If they were effected by contraction of the ſtomach alone, that mixus which is made uſe of to produce them would not have place; but the diaphragm and muſcles of the thorax and abdomen would be as tranquil as in ordinary deglutition. That the muſcular fibres of the urinary bladder are not at all under the controul of the will, appears evi-

dent from the application of the catheter. And if the hiſtory of the Engliſh military tribune's having the power of ſuppreſſing, at his diſcretion, the motion of his heart and arteries, as related by Baynard and Cheyne be correct, muſt not this alſo have been produced by ſuch diſpoſition of the diaphragm and conſpiring muſcles, as would cauſe a conſtriction on the *cava aſcendens* and *aorta deſcendens* in ſuch a way as to interrupt diſtinct pulſation for a ſhort while, by arreſting, not wholly, the contraction of the left ventricle, and withholding, not wholly, from the right ventricleits ſtimulus, rather than from any effect, produced immediately upon the heart, and which might be attended with conſequences mortal in the brain. Perhaps a total ſuppreſſion of the heart's motions, and of the circulation of the blood in the brain, would, except under the relaxation of ſyncope, be attended with immediate death.

On conſideration of the ſubject of palpitation, an unlimited field of inſuperably difficult reſearch preſents itſelf, which I do not dare to enter any farther; already feeling myſelf bewildered, in attempting to reduce the different inordinate motions of the heart, to two diſtinct kinds of palpitation, and in attempting to refer differently produced agitations to one or other of theſe two claſſes, which are, perhaps, without any foundation in nature.

For if, after all, the muſcular part of the heart be without ſenſibility, and without diſtinct nerve, and its irritability be only excited by the ſtimulus of the blood, or by diſtenſion from its received volume, then muſt not palpitation always be the effect, and not the cauſe, of diſturbed circulation. Even in the caſe, if ſuch there be, of the affection beginning through the coronary veſſels being influenced by their nerves, muſt not we conſider all this as paſſing externally, with regard to the muſcular ſubſtance of the heart?

When palpitation ariſes from derangement in the ſtructure, and from unequal or morbid diſtribution of vital power, in different parts of the heart, if this can have place, ſuch, and perhaps ſuch only, are the caſes (at least with exception of ſtimulating matter getting into the ſyſtem, whether from the alimentary canal or externally,) where it is the cauſe and not the effect of disturbed circulation.

Diviſion of palpitations into permanent and excited.

26. In conſidering theſe things, another, a rather different, the more ſimple or ſtrict, diviſion into excited and permanent, preſents itſelf.

On this more accurate diviſion, I may repoſe a while, without ſuch immediate danger of being bewildered.

Taking the word *palpitation* in the most extenſive ſenſe, I conſider it to ſignify every deviation, from regular and undisturbed motion, in the heart.

27. Excited palpitation ariſes from exceſs or defect of ſtimuli of every kind, and of excitability.

In the caſe of exceſs, the pulſe is vigorous and quick;

In the caſe of defect, it is tremulous; and, from the ventricles, feeble as are their contractions, having occaſionally to wait for ſtimulus or excitability to accumulate, to effect them, intermittent.

Irregularities produced, in the motions of the heart, or in the circulation, by increaſe or diminution of excitement, may mark the progreſs of diſeaſe or infirmity, or the efforts (as ſome think) of the vital principle to reſtore health.

28. Permanent palpitation ariſes from derangement in the ſtructure of the heart, or from diſproportionate diſtribution of ſtrength and vital power in the different parts of it.

Palpitation, by deranged ſtructure, from a ſenſible agitation on the thorax, and in the general circulation, to ſcarcely diſtinguiſhable intermiſſion, may ſometimes be obſerved in people enjoying tolerable health.

In general they can badly bear violent exerciſe or other ſtrong excitement. Sometimes, however, a certain increaſed, perhaps at others, a diminiſhed, excitement overcomes the ſlight cauſe of regularity.

In this way the pulſe ſometimes ceaſes to intermit under diſeaſe; and on the patient's recovery, the intermiſſion returns.

A certain degree of almoſt every deſcription of diſeaſe may produce palpitation; and almoſt every cauſe of palpitation can alſo produce ſyncope.

29. Palpitation is ſometimes a ſlight and temporary indiſpoſition, ſometimes an incurable malady; finally palpitations often accompany the labouring efforts of departing life; and, on the laſt expiration, a laſt ſhudder or palpitation is terminated by the ſyncope of death.

30. It is ſaid that in the dying the left ventricle ſtops firſt, then the ſinus on the ſame ſide, owing to the blood being effete or unfit for further uſe from the defect of breath, and from its being more ſparingly tranſmitted through the lungs, afterwards the right ventricle, and laſtly the right ſinus ceaſe to contract: that hence it ſometimes happens, that the blood may in ſome meaſure be obliged to return in the aſcending and deſcending *cavae*, and may affect a ſlight motion in them.

If ſuch be the termination of life, we may ſee how the laſt palpitations of the heart may be ſtronger than thoſe which preceded them, by the ventricles ceaſing to act ſynchronouſly; for we can hardly refer ſuch action to ſpaſm, if this can have place in the heart. I have obſerved in caſe of triſmus that, previous to death, the ſpaſm has ceaſed and the jaw become looſe; and in death is there not extreme relaxation in all the muſcular fibres of the body from their being deprived of all excitement?

General obſervations on life.

31. In this eſſay the ſanguiferous ſyſtem of veſſels has been conſidered, chiefly as a complicated hydraulic machine, the ſtimulus of the blood, itſelf, exciting the propelling influence which effects its own circulation; and but little has been offered on the vital principle which modifies in ſo wonderful a manner the actions of chemical agents and even, in a certain degree, the effects of phyſical combinations, that we cannot reduce what paſſes in our bodies, to the rules which are obſerved in the inanimate creation.

Senſation, in the different parts of our bodies, which are ſenſile (for although the cauſe be incomprehenſible, the different parts of it are well known to vary extremely in their ſenſility; while in ſome parts this is exquiſite, in others the ſenſation, if it have ever exiſted, is ſo loſt, that we are not conſcious of pain or injury, while their life and ſtructure are a deſtroying.)

Senſation ſeems to be derived from the brain through the nerves; or rather, the brain itſelf, the ſeat of ſenſation, or the mind, as eminently reſiding, or concentrated in that organ, derives feeling or knowledge of the objects of the ſenſes through the nerves.

And through the medium of the nerves, the muſcles, obedient to the will, are called into action.

If nerves be deſtroyed, the life of the part to which they lead is loſt.

32. Hence we might be ready to conſider the brain as the ſource of vitality; but, among the various inſtances of monſtroſity, the *foetus in utero* without brain, in other reſpects well-formed, is found to live and thrive till the time of birth when it immediately expires, or rather dies, on coming into the world.

In this caſe the reaction of the blood, from the ſtoppage through the umbilical cord, towards unfolding the lungs is of no avail. (19. *b.*) It never reſpires.

While, as has already been obſerved, the muſcular part of the heart ſeems to be without diſtinct nerve; and the lower claſſes of animals are many of them without brain, and approach ſo nearly to plants, in their nature and ſtructure, that it becomes inſuperably difficult to draw the line which divides the animal and vegetable departments from each other.

33. The medullary ſubſtance of the brain occupies the internal part; the cortical, the external.

This diſpoſition of ſubſtance is tranſpoſed in the nerves, the medullary part being external.

Is it neceſſary to thought and to intenſe feeling, that there ſhould be concentration of medullary ſubſtance as in the head, a root or ſource, while there is a more univerſal diffuſion of it throughout the nervous branches or ſtreams, by its forming the external ſurface, untenacious, and extremely affinitive with every fibre of living organiſed matter, (and covered only with an extremely fine continuation of the *pia mater*, which may be as pervious, to whatever is effuſed from the medullary ſubſtance, in order to nutrition, to muſcular action, to ſuſceptibility of impreſſion, &c. as is the membrane of the air cells of the lungs, to whatever the blood has to give off or to receive, in its paſſage through that organ) that mind may act, and be acted upon more univerſally.

As liability to death, acuteneſs of ſenſibility and intellect ſeem to be great, in proportion as quantity of brain exceeds that of nerve, does tenacity of life, in the lower animals, ariſe from general diffuſion of nervous ſubſtance throughout their bodies? Is it to this that parts, even limbs, of them being deſtroyed, new organization and reſtitution of parts take place, the life of theſe not depending ſo much on a diſtinct organ, as in large brained animals, in which a ſimilar violence would produce exquiſite pain and death?

Is the diffuſion of nervous ſubſtance ſtill more general through plants? are they, therefore, happily leſs ſuceptible of pain than animals, while their capacities for pleaſure are ſo limited?

Is it owing to this univeral diffuſion of vital principle, in ſome plants, that on almoſt any part or fibre of them being placed under proper circumſtances, a complete plant is thereby produced?

And while many animals ſleep for a ſeaſon, do not plants and their ſeeds ſleep for ages? When parts in Holland that have lain ſo long under water are drained, cheſnuts are found, and trees of this deſcription ſpring up on the ſurface of the earth being expoſed to the air.

34. Do the cryſtalliſations, in the mineral department, in ſome inſtances, ſhew a tendency to organiſation? Is that which is the life of the loweſt or moſt ſimple plants, ſometimes diffuſed to mineral arrangements of matter, ſo as to produce organiſation? And do plants or vegetable fibres become animaliſed in like manner, without thoſe changes being produced,

by elaboration of alimentary parts in bodies already organiſed and living, which proceſs is the continual ſupport, and the continual labour, of living bodies?

What may go on in parts, where the microſcope does not reach, we can only judge of by analogy; and we do not ſee, in what falls under our view, any thing to render ſuch conjectures probable. We feel ourſelves obliged in conſideration of theſe things, to refer the origin of every organiſed production, to a diſtinct creation of original parent, no other alternative offering itſelf, than the ſuppoſition that their ſucceſſion has been continued from all eternity, and that there is no exiſtence of firſt cauſe.

25 The vital principle in the human body may be ſtrong, when the intellectual one is weak, (is ſtrongeſt in thoſe animals where this is the weakeſt) and the mind may be clear and comprehenſive, when life is on the verge of departure from a body exhausted and tabid.

For human ſagacity to attempt to develope the beginning of life, the nature of the vital and intellectual principles, their connection with organiſed matter, muſt always be as abortive, as would be the attempt in created beings to realiſe the monſtrous fiction of Prometheus.

They are beyond the comprehenſion of the human underſtanding. We can do little more than obſerve their actions upon each other. The utmoſt conqueſt that can ever be obtained by the healing art is to give to them ſometimes a little ſeaſonable modification, to keep up the balance between different jarring functions, by affording aid to the part which is oppreſſed, or by taking away force from the part which acts with violence.

III. ON THE TREATMENT OF ANIMALS.

I MIGHT here cloſe this eſſay, but cannot feel ſatisfied in my mind, without ſaying ſomething on the treatment of animals.

Abuſe and torture.

WHEN theſe our humble partners in creation, are harraſſed for the gratification of the ſportſman, or the voluptnary; when they are ill treated, from motives of avarice, we readily revolt at the cruelty: but when the phyſiologiſt puts them on the rack, he ſacrifices their eaſe, and perhaps his own feelings, for the advancement of ſcience, for the good of mankind. But has he a right to torture them for the

good of mankind? A conviction ſo ſtrong reſts upon my mind that we have no right to leſſen their portion, while living, of the enjoyments of animal life, that I cannot conſider hardſhips impoſed upon them, in any way, greater than thoſe we are ourſelves willing to undergo, in proportion to our ſtrength and powers, leſs acts of injuſtice, than if they had been exerciſed upon our own ſpecies. We have no right but that of force.

I believe there are no facts, brought forward in this paper, which may not have been derived from diſſection of dead bodies, from obſervations made by ſurgeons on their patients, from ſeizing the occaſions of watching what paſſes in dying animals killed by accident or deſign in the moſt rapid manner, and from analogical reaſoning; and if the diſcovery of any phyſical truth, however important, can only be obtained by the infliction of an additional (involuntarily received) pang upon any fellow partaker of mortality, whether brute or human creature, it is the ardent deſire of my heart that it may never be ſealed upon my brain, that the world may never know it.

The reaſon offered for theſe remarks will be a ſufficient apology with the candid, for the liſm they contain, and will make them bear alſo with patience what I am yet going to obſerve farther.

Deprivation of life.

37. If I be queſtioned, by what right I make uſe of animal food? My anſwer is,---I do not hereby break the eternal law of juſtice which requires us to do as we would be done by. For were a metempſychoſis to exiſt, and could I chooſe what ſhould be my lot in a future ſtate of exiſtence, when my ſpirit ſhould animate the body of a brute creature, I ſhould not have any objection againſt future men cutting ſhort ſuch manner of life for any uſeful purpoſe: I ſhould even bequeath my future living body to phyſiologiſts, with as little reluctance, as I ſhould now my preſent one when dead for diſſection, provided they were not to alarm the fears of the mute animal: Let me now be aſſured, in ſuch caſe, that they would decoy the

unſuſpecting brute to receive the effective mortal ſhock of an electrical battery, or to fall under the ſtroke which ſhould inſtantly divide, or deſtroy, the ſtructure of the brain or *medulla oblongata*, or remove the whole head, upon which they might ſeize the occaſion of breaking open the quivering trunk to ſee what paſſed, and it would afford a gratification to me to know, that I ſhould not have to bear the infirmities, nor to ſuffer the pains incident to old age. In ſhort, ſuch is the preſent lot of the ſenſitive part of the creation, that on man, who has the hope of immortality to conſole him, and who has alſo, during the tottering ſteps of his pilgrimage, the means of affording intellectual gratifications to his friends, of ſtirring up the moſt heavenly feelings of the ſoul, while he is himſelf cheriſhed by their ſympathies in declining life, — on man alone I can contemplate the marks of old age with gratulation.

Reſpect to the ſocial affections.

But while man ſtands ſo eminently diſtinguiſhed, above all his fellow creatures, there ſeems alſo ſome attention due to the affections and ſocial feelings of the brute. Under the window where I write this paper, a horſe ſhews evident marks of anxiety on the diſappearance of his comrade horſe, who has walked off with his load. On the ſound of his returning feet, he lifts up his head with pleaſure, and neighs his welcome, when he comes into view.

Ought I to be diſquieted at the yelping of the dog, left alone aboard a veſſel in the haven? He is wretched without company, and, on the return of the people, friſks about with joy, and lets me continue my paper without interruption.

All theſe emotions, however, and all other affections ſeem feeble when compared with the ſolicitudes and raptures of dams tending their young.

Who, in conſidering theſe things, could unreluctantly break in upon the felicity of the bird's neſt? Who could in any wiſe be willing to ſeethe the kid in the mother's milk?

FINIS.

POSTSCRIPT.

IN the printing of this eſſay there has, by an overſight, been omitted the inſertion of a part of it reſpecting the probable intention or uſe of the placental blood, being ſent to the liver, inſtead of its being directly propelled to the heart or to the cava. If my conjectures on this have been right it forms a part not unimportant, of '*the wonderful proviſion for the tranſition from the foetal to the breathing ſtate.*'—from that ſtate in which the homuncule derived its nutriment like a vegetable through roots without its own body, to that of its feeding by the mouth, when its principal roots, the lacteals, and we may add alſo the pulmonary veins, are found within itſelf.

The blood coming from the parent is of the arterial kind, tho' not paſſing through the *placenta* with rapidity it be leſs oxygenated than that which is contained in the arteries of the parent. In fact there being no detectable paſſage of venous blood through the *placenta* to the mother, nor of arterial from her to the foetus, nutriment is diſtilled in a way ſo gentle as to prevent the detachment of the child from the parent. Its circulation goes on uninterruptedly, while that of the mother is liable to be quickened or to become irregular from various cauſes. The nutriment is ſupplied through channels ſo minute and by a fluid ſo ineffably fine, that both the veſſels and their contents elude the reſearch of the moſt acute obſervers. The changes then of the blood in the foetus and the parent, while the latter continually receives carbone from the former, and at the ſame time ſupplies it with oxygene, ſeem to be effected by juxta poſition of the maternal and foetal parts of the *placenta*.

The blood from the *placenta* paſſes through the umbilical vein, penetrates the body at the umbilical ring, ſeeks the liver, and is poured into the ſinus of the *vena portarum*, whence it paſſes partly through the branches of the *vena portarum* diſtributed throughout the liver, and partly through the *ductus venoſus* by a direct way to the *vena cava*.

Thus the veſſels of the liver are kept ſufficiently dilated, by oxygenated blood, for the reception of carbonated or hydrogenated blood after birth, in ſufficient quantity for the neceſſary ſecretion of bile, when the animal ſeparated from the parent, ſhall have to digeſt food for itſelf.

The younger the foetus is, the larger is the liver in proportion to the reſt of the body. At an early period of its exiſtence, it is chiefly placental blood which paſſes through it.

As the abdominal viſcera are unfolded, and their venous blood in greater quantity conſequently enters the liver, a greater quantity of placental blood is determined through the *ductus venoſus*. Bile begins to be ſecreted, and paſſing into the inteſtines, forms the meconium.

* *

Thus the digeſtive organs of the foetus begin to be exerciſed, and thus it is prepared for that period when it muſt take its nutriment by the mouth.

At that time it is only the moſt deeply carbonated, or hydrogenated, blood from the abdominal viſcera that enters the ſyſtem of the *vena portarum*, furniſhes to the liver the elements of bile and thus effectually ſtimulates the organ to the neceſſary ſecretion.

Does this deſcription of blood ever flow in too large a quantity previouslv to birth, or even for a ſhort while after it? If ſo, it may find a paſſage through the *ductus venoſus* before its cloſing.

Does this happen, particularly, at the moment of the birth, when the current in the *aorta deſcendens*, produced by the contraction of both ventricles, no longer finding a paſſage through the umbilical arteries, is driven with ſudden and unuſual force into the hepatic artery, producing, perhaps, ſuch enlargement in its ramifications, which are hereafter ſolely to ſupply nutriment to this immenſe organ, as may cauſe the blood to be expreſſed from the larger veſſels of the *vena portarum* retrogreſſively; while that in the ſmaller ones and in thoſe which ariſe from the combinations of theſe, that is, in the large hepatic veins, may by the ſame force of preſſure be accelerated to the cava.

Edinburgh, 21. j. 1800.—It has occured to me that the blood which paſſes through the *foramen ovale* is ſent principally from the inferior rather than from the ſuperior *cava*, with the intention that the left ventricle may be accuſtomed to the ſtimulus of the blood, in ſome degree oxygenated, previous to birth; after which it will have to receive only that which has been oxygenated from reſpiration; and, that the right ventricle may, at the ſame time, in a great meaſure eſcape the effect of ſuch ſtimulus, becauſe it will, after birth, have only to receive the blood which has paſſed through the greater ſyſtem, and which has conſequently loſt its oxygen.

Since my forming theſe concluſions, I learn that Winſlow, Haller, Sabbatier, and a number of other Phyſiologiſts, have concluded that the uſe of the Euſtachian valve, in conducting the blood in the *foetus* from the *cava inferior* through the *foramen ovale*, is to carry the blood (recently arrived from the *placenta*) more immediately, through the left ſide of the heart, to the head and upper parts of the body, before it enter the right ventricle, (which it principally does on its return through the ſuperior *cava*) to be propelled by it through the *ductus arterioſus* to the *placenta*, and lower parts. To this alſo the *Tuberculum Loweri* ſeems to contribute, in diverting the blood from the ſuperior *cava* from directly meeting that from the inferior *cava*: and theſe proviſions for preventing the direct concuſſion of the ſtreams from the two *cavæ*, uſeful throughout life, may be particularly ſo in the *foetus*, when, with its head downwards in the *uterus*, the larger column of blood in the inferior *cava* gravitates by its poſition in a direction oppoſed to the current of the ſuperior *cava*.

Previous to birth, the whole maſs of blood has to paſs through the inferior *cava*,---diſpoſition which is afterwards, in ſome ſort, reverſed, when chyle and lymph, elements of the blood, paſſing continually through the thoracic duct, are diſtilled into the left ſubclavian vein, and thus become mixed with that part of the general maſs which falls from the ſuperior *cava*. But previous to birth, the general maſs of blood, as regenerated in the *placenta*, has continually to paſs through the inferior *cava* to the heart.

Theſe proviſions of valve and ventricle ſeem both to be produced by the oppoſing currents of the *cavæ* which they regulate or guide; as, in the whole œconomy of undiſturbed creation, every production ſeems to ariſe from the neceſſity there was for its preſence, or rather it ariſes coevally with that neceſſity.

In reflecting upon this beautiful theory, I am led to think, that the placental blood, in ſo immediately entering the liver, nouriſhes that organ, or, may I ſay forms, as well as keeps ſufficiently enlarged, its veſſels intended for biliſication; and that the nutriment to the different parts of the *foetal* ſyſtem is afforded, in a quantity greater or leſs, accordingly as the blood arrives ſooner or later from the *placenta*, or as it is leſs or more mixed with that blood which has already in circulation depoſed its nutriment in other parts.

If ſo, then, we may eaſily ſee how it happens that the liver is ſo large during the foetal ſtate.

The blood from the umbilical vein, in a ſtate extremely nutritive, partly permeates the liver, and nouriſhes it; it partly paſſes through the *ductus veno/us*, and with much greater velocity, to the inferior *cava*, where the ſeparated ſtreams again unite into one current.

The blood arriving here from the Hepatic vein, has been deteriorated in affording nourishment to the liver, and by the admixture of that blood which is conveyed from the abdominal viſcera through the *vena portarum*: a ſmall quantity of deteriorated blood alſo arrives from the abdominal *cava*. But owing to the great quantity of placental blood arriving here, in conſequence of the ſuperior velocity of the current in the *ductus veno/us*, the whole mixed current entering the right auricle from the inferior *cava* is yet highly nutritive, not leſs ſo than the firſt mixture which had place in the liver. It makes its way principally through the *foramen ovale*, and left ſide of the heart, to the brain and the upper parts of the body. Hence ariſes very great enlargement of the liver, the head and thoracic *viſcera*. The blood returns carbonated or deteriorated through the ſuperior *cava* to the right auricle, in order to paſs to the right ventricle, and thence to be propelled through the *ductus arterio/us*, *aorta deſcendens*, the iliac and umbilical arteries, to the

placenta. If the blood paſſing through the *ductus arteriosus*, completely filled the part of the *aorta*, which it enters and permeates, this would utterly prevent any blood from being propelled through it from the left ventricle: but the abdominal viſcera, and lower extremities, have need of nutriment alſo; and part of the blood, ſent from the inferior *cava* to the left ventricle, paſſes through the *aorta deſcendens*; moreover, as the blood from the inferior *cava* does not paſs through the right auricle in a diſtinct canal, a part of it mixes with the blood from the ſuperior *cava*, as it paſſes to the right ventricle. Thus through two ſources is blood, highly nutritive, afforded to the remaining abdominal viſcera, and the lower parts of the body; but from its being mixed with ſo large a quantity of carbonated blood, the parts, particularly the pelvis and lower limbs, are not ſo well nourished. Beſides, the greateſt part of this blood paſſes off through the umbilical veins to the *placenta*, to be regenerated. Thus too great a growth in the whole *foetus* may be ſaid to be prevented, by the ſtinting of the parts not immediately eſſential to life; or rather, by this ſtinting, the greater quantity of nutriment is determined to the parts moſt eſſential to its exiſtence.

It is neceſſary that the child breathe on its firſt coming into the world. It has immediate uſe for its digeſtive powers. Its organs of ſenſe are one after another called into play. It muſt depend for a time on the breaſt for ſupport; and, even in the act of ſucking, its organs of ſpeech acquire ſtrength. In the mean time, the vivifying current, heretofore partially diſtributed through its ſyſtem, now diffuſing itſelf more equably, gives ſtrength to thoſe parts, which are ſhortly to relieve the fond parent from her burden ſtill pleaſing, but becoming, at length, too heavy for her arms. In the amuſement of its early years, its organs acquire ſtrength, its mental powers are awakened; but not, till the age of puberty, is the whole ſyſtem evolved. Through ripening years, the heart ſtill beats high, the arterial action is ſtrong, the current ſets through the venous ſyſtem with conſiderable rapidity, till the veins, at length, ſufficiently dilated, receive, in declining age, with leſs reſiſtance, the crimſon ſtream now ſent with diminiſhed force, by a heart which fails to give its former youthful ſtroke, and through arteries now enfeebled, and participating in the general weakneſs; while the mental powers alſo fail with increaſing years, and unequivocally announce the approach of that event, which, whenever it arrives, levels every diſtinction of vain man.

SPECIMEN ACADEMICUM

INAUGURALE,

SISTENS

THESES ALIQUOT MEDICAS,

Quas, annuente Summo Numine,
Rector magnificus

MEINARDUS SIMON DU PUI,

A.L.M. Med. et Phil. Doct. Chir. Pract. et Art. Obstetr.
nec non Collegii Practico-Medici Prof. Ordin.

Amplissimo Senatu Academico consentiente, et ex Decreto Nobilissimae Facultatis Medicae,

PRO GRADU DOCTORATUS,

Summisque in MEDICINA Honoribus ac Privilegiis

IN ACADEMIA LUGDUNO-BATAVA,

rite ac legitime consequendis.

Eruditorum Examini submittere permisit

JOHANNI WALKER,

ANGLO.

Ad diem XXX. *Julii* MDCCXCIX. *H. L. Q. S.*

Johannes Walker, Gulielmo Saunders ſuo primò in arte Medica Præceptori.

Cogites forſan, cogitent quoque Collegae tui, docentes artem Medicam in aedibus à Thoma Guy fundatis, Gulielmus Babington nempe & Johannes Haighton; nec non Henricus Cline, & Aſtley Paſton Cooper in Noſocomio Sancti Thomae ſic dicto, docentes, fautores omnes mei; cogitent Conſocii ſocietatum Medicarum & Phyſicarum Noſocomiorum Guyii & Bartholomaei, Amici omnes cum multis aliis, quibus hoc qualecunque Specimen offerre mihi animus eſt, meum fuiſſe officium majorem inauguralem Diſſertationem producere, quoniam opportunitas frequens multa audiendi & videndi mihi contigerat, tum Domi tum in diverſis terrae tractibus, ubi cum Ariſtippo, in naufragio tranſvecto in Littora incognita & recognoſcenti in arena mathematicarum figurarum lineas non exclamo—" Bene " ſperemus: nam veſtigia hominum video"—ſed potius atteſtor peregrinans—" Homines vidi & beneficia accepi " & gratificationes percepi."

Britanni venite & videte;—nam timeo, quicunque fructus Religionis, Philoſophiae, Artium, Commercii, &c. continue advenerint in inſulas veſtras, quacunque ab orbis parte, ne plerique veſtrum longius manſiſſetis, quam ego remanſi, ſeparati ab hominum mundo, per praejudicium domicilii et partium ſtudium, ſicuti ſolum noſtrum natale ab continenti ſeparatur per maris undas.

At ad apologiam redire me oportet.

Mi Praeceptor! Occupatus deinde fui, ut producerem Diſſertationem de Phyſiologia et Pathologia Menſtruationis: ſed cum ad tale argumentum, fere nihil niſi quaſdam aliorum obſervationes conflare potuiſſem, tunc idea mihi in mentem venit de neceſſitate cavitatum contractilium inter truncos venoſos & cordis ventriculos & uſu ſinuum venoſorum in encephalo cum rebus aliis. Ad Diſſertationem Inauguralem hanc parandum multos dies, heb-

domades, nec non menſes conſumſi, ſed tempus, quo Theſes Inaugurales offerendae mihi erant, cum nimium breve eſſet eam relinquere coactus fui.

Celerrime ergo Theſes aliquot in lucem edere coactus fui, quas hoc momento in mentem mihi venerunt, nam antea quid offerre plane inconſultum mihi fuit. Ecce nunc productionem tot horarum, quot annos ſolum natale reliqui.

Quamquam morbo Helvetico (Noſtalgia) affectus non ſum, ſpero fore, ut cito ad vos redeam. Vale.

Datum Lugd. Bat. 29. vij. 1799.

Rectori et Senatui Academiae Lugduno-Batavorum.

MEMORIAM veſtrae benignitatis, qui *religionem* honore habuiſtis ſpero ſupra omnem laudem gratificationem ſemper praebituram. Nam me in veſtra univerſitate promovendum, mores quaſdam antiquas (etsi pluribus ſacras mihi tamen opinionibus obstatas) ad obſervandum me cogere nunquam *conati fuiſtis.*

J. W.

Rotterodami, 6. viii. 1799.

SPECIMEN ACADEMICUM

INAUGURALE,

SISTENS

THESES ALIQUOT MEDICAS.

CIRCULATIO IMPERTURBATA.

1. Oportet ventriculorum cordis dextrum propellere ſanguinem per ſyſtema pulmonale.

2. Oportet ventriculum ſiniſtrum propellere eum per ſyſtema majus vaſorum ſanguiferorum—partes tenuiores ejus per vaſa ſeroſa & exhalantia—& partes mutatas, fortaſſe, per ductus excretorios organorum ſecernentium.

3. Neceſſe eſt quod ventriculi ſiniſtri contractiones fortiores ſint dextri.

4. Sanguis carbonatus non tantum ſtimulat, quantum oxygenatus.

5. Sanguis, qui in ſinum & ventriculum dextrum accipitur, maxime eſt carbonatus.

6. Qui in ſiniſtrum accipitur, maxime eſt oxygenatus.

7. In circulatione imperturbata ventriculus cordis ſiniſter plus ſtimulatur a ſanguine quam dexter.

CIRCULATIO ACCELERATA.

8. Per preſſionem muſculoſam contra venas ſanguis, tranſiens a loco preſſionis ad cor, acceleratur in ejus motu.

9. Hoc cordis dilatationem producit.

10. Dilatatione fit ejus actio intenſior.

11. Per preſſionem muſculoſam contra venas ſanguis, veniens a corde ad locum preſſionis, impeditur in ejus curſu.

12. Valvulae in venas impediunt reactionis propagationem ad inſignem diſtantiam rotrogradam.

13. Ab interruptione ad locum preſſionis, & a vi a tergo, ſanguis per vaſa anaſtomotica in venas cutaneas tranſire cogitur.

14. Non multum ſubjecta ſunt vaſa cutanea preſſioni muſculari.

15. Acceleratur circulatio univerſalis.

16. Accelerantur functiones.

17. Sanguis perdit oxygenium velocius ſyſtemate majore.

18. Et velocius carboniſatur.

19. Corporis calor augetur.

20. Ut utriuſque ventriculi ſanguis differat, carbonium debet abduci illo tempore, quo pellitur per pulmones, nempe ab uno ventriculo ad alterum,

21. Et oxygenium debet adduci majori velocitate, quam ſi tranſeat rapiditate minori.

22. Acceleratur reſpiratio.

23. In circulatione accelerata plus ſtimulatur ventriculus ſiniſter quam dexter.

VITA MUTABILIS.

24. Sunt fibrae viventes, quae ad actionem ſtimulantur.

25. Fibrae animales mortuae non habent aptitudinem motus.

26. Quod, quum accidat per corporis extranei contactum, effectus eſt attractionis chemicae; quod ſi autem actio quaecunque mechanica ceſſet agere in illas, omnis actio illarum inde emergens effectus eſt vis mortuae cujuscunque praeter actionem quae repetenda ab illarum ſtructura organica.

27. Sine motibus internis, niſi quae ad decompoſitionem ducunt, manet corporis organiſatio poſtquam abiit illa vita, quae ſtructuram producebat & quae in eo reſidebat unice per motus eos, qui in ſtructuram illam locum habebant a momento eo, quo initium mutuum habebat, ut loquimur, vita corporis cum organiſatione ejus.

28. Ab applicatione cauſarum morboſarum ad corpora viventia excitatur principium vitale, ut hoſtem vitae repellat per actionem organicam incitatam

29. Si vis repellens excedat aut deficiat; in utroque caſu, effectus nocivus eſt.

30. Vis repellens adeo deficere poteſt, ut cauſa morboſa mortem inferat per repreſſionem actionis vitalis.

31. Ita excedere poteſt vis repellens, ut deſtruat ſtructuram organicam adeoque actionem vitalem.

32. Sine qua actione vitali, non locum habet vita, in ullo corpore organico.

33. Per ipſam actionem vitalem tandem deſtruuntur omnia corpora organica, niſi occiſa ſint per hoſtem extraneum.

ARS MEDICA.

38. Officium eſt medici remedia contrarium effectum cauſarum morbi producentia adhibere, quibus cauſae morboſae, ſive ſtimulantes ſive ſedativae, amoveri queant. Tum tranſit ſaepe ad ſanitatis ſtatum aegrotans.

35. Perfectio artis medicae conſiſtit in efficiendo quod effectus remedii & cauſae morboſae invicem deleantur.

36. Adminiſtratio remediorum contra cauſas morboſas, ſi non adſint, eſt nihil niſi applicatio cauſae morboſae.

37. Ut remedia feliciter adhibeantur neceſſe eſt, ut diſtinctionem facere diſcatur inter ſymptomata, quae demon-

ſtrant mutationes actionum vitalium, quae tendunt ſanitatem producere, & ea quae oſtendunt mutationes, quae eam nocent aut nocere tendunt.

38. Haec diſtinctio fundamentum medicae artis eſt.

39. Perfectiſſima ſanitas locum habet ſi adeſt fortiſſima actio vitalis, quam ſuſtentare poteſt corpus organicum, ſine ejus inevitabili deſtructione accelerata.

40. Gaudet in vita, eo tempore, creatura.

41. Ars medica utilis eſſe poteſt.

TANTUM.

Printed at Edinburgh by T. Maccliesh & Co.